



Whose resilience matters? Like-for-like comparison of objective and subjective evaluations of resilience

Lindsey Jones^{a,b}, Marco d'Errico^{c,*}

^a London School of Economics and Political Science, Grantham Resilience Institute for Climate Change and Environment, London, United Kingdom

^b Overseas Development Institute, London, United Kingdom

^c Food and Agriculture Organization of United Nations, Viale delle Terme di Caracalla, 00100 Rome, Italy

ARTICLE INFO

Article history:

Accepted 29 July 2019

Available online 16 August 2019

Keywords:

Resilience

Subjective measures

Quantitative

Perceived resilience

ABSTRACT

As resilience continues its rise to top of the international policy agenda, development funders and practitioners are under mounting pressure to ensure that investments in resilience-building are effective and targeted at those most in need. It is here that robust resilience measurement can make valuable contributions: identifying hotspots; understanding drivers; and inferring impact. To date, resilience measurement has been dominated by objectively-oriented approaches. These rely on external definitions of resilience (often informed by outside 'experts', literature reviews or resilience practitioners) and measured through observation or external verification. More recently, the potential for subjective approaches has been proposed. These take a contrasting approach, soliciting people's judgements of what resilience means to them, and getting them to self-evaluate their own resilience.

While both approaches have their strength and weaknesses, little is known about how objective and subjective modes of resilience measurement compare. To shed light on this relationship, we provide like-for-like comparisons of these two approaches using a regionally representative household survey of 2308 households in Northern Uganda. In so doing, we introduce a new measurement approach named the Subjective Self-Evaluated Resilience Score (SERS). Outcomes from SERS are directly compared with an objectively-evaluated approach, the Resilience Index Measurement Analysis (RIMA), widely used by resilience practitioners.

Findings from the survey suggest a moderate correlation between objectively- and subjectively-evaluated resilience modules. More importantly, both approaches share similar associations with many key socio-economic drivers of resilience. However, there are notable differences between the two. In some case, the approaches differ entirely regarding contributions of important traits, including coping strategies, levels of education and exposure to prior shocks. Our results highlight the need for resilience evaluators to consider a diversity of knowledge sources and seek greater use of evidence in indicator selection. We also investigate the properties of the SERS module itself. We find that characterisations of resilience that mimic various commonly-used frameworks produce similar resilience outcomes, suggesting that debates over the exact composition of resilience-characteristics may matter little. In addition, shorter SERS modules match the performance of the full set of SERS questions, allowing for quicker administration and reduced survey burden. Lastly, we call for evaluators to consider the strengths and weaknesses of subjective and objective measurement approaches, including options for combining both formats.

© 2019 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Resilience has rapidly risen to the fore of the international development agenda (Roberts, Andrei, Huq, & Flint, 2015). As political support for resilience-building grows, funders and

practitioners need better ways of evaluating the effectiveness of their resilience-building interventions (COSA, 2017). A wide range of measurement approaches have recently sprouted seeking to address this need (Schipper & Langston, 2015; Brooks, Faget, & Hiejkoop, 2019). To date, the vast majority of these rely on objective forms of measurement (Bahadur & Pichon, 2017). Broadly speaking, objective approaches can be described as those reliant on judgements and observations external to those being measured. Here objectivity can relate to two aspects: how resilience is defined,

* Corresponding author.

E-mail addresses: L.Jones3@lse.ac.uk (L. Jones), Marco.derrico@fao.org (M. d'Errico).

i.e. who decides what resilience is and the characteristics that make a household resilient?; and how it is *measured*, i.e. is resilience measured by means of external observation or self-assessed judgements? (Jones, 2019).

Objective approaches to resilience measurement have many advantages. Most use fixed and transparent definitions of resilience (Clare, Sagynbekova, Singer, Bene, & Rahmanberdi, 2018; Beauchamp, 2019); allow for different groups of people to be compared through standardised metrics (COSA, 2017); and rely on proxy indicators, many of which are routinely collected by governments and development agencies (Schipper & Langston, 2015). Yet they are not without their weaknesses (Levine, 2014). For one, agreeing on a common set of resilience indicators has so far proven a considerable challenge – despite numerous syntheses and technical reviews (Schipper & Langston, 2015; Bahadur & Pichon, 2017; FSIN, 2014).

In addition, while household resilience is partly driven by the availability of physical assets and infrastructure, much of it relates to 'soft' elements. These intangible processes – such as community cohesion or social capital – are difficult to see or measure (Adger, 1999). As a result, objectively-evaluated tools often use large lists of proxy indicators to try and account for them (Bahadur & Pichon, 2017). Doing so requires significant amounts of socioeconomic data – much of which difficult to collect and unavailable across the Global South (COSA, 2017). More worryingly, a preference to opt for more easily quantifiable capacities not only risks skewing measurement outcomes but shifts consensus narratives on resilience determinants (Clare et al., 2018).

Most importantly, objective approaches do not currently take into account the wealth of knowledge that people have of their own resilience and contextual information that can help inform it (Marshall & Marshall, 2010). This includes important internal factors such as mental states, aspirations and psychological resilience. Each of which is fundamental in shaping how households react in the face of external threats (Cox & Perry, 2011). With these factors in mind, alternative methods of resilience measurement have recently been sought (Maxwell, Constanas, Frankenberger, Klaus, & Mock, 2015).

One promising approach comes in the form of subjective tools for assessment (Marshall, 2010; Jones & Tanner, 2017; Jones & Samman, 2016; Claire, Graber, Jones, & Conway, 2017; Seara, Clay, & Colburn, 2016; Nguyen & James, 2013; Béné et al., 2016a; Sutton & Tobin, 2012). Subjective approaches start from the premise that people have a legitimate understanding of the risks they face (Jones, 2019). As with objective measures, subjective approaches can relate either to how resilience is defined or how it's evaluated. They use people's own judgement of what constitutes resilience and self-evaluations of their ability to deal with risk. Crucially they place few, if any, constraints on what a respondent should consider in assessing their own resilience: measurement is largely directly by the respondent themselves¹.

Subjective tools have been trialled in a number of different contexts (Jones & Samman, 2016; Marshall, 2010; Seara et al., 2016; Nguyen & James, 2013; Béné et al., 2016a), and may provide a useful complement to traditional objective approaches (Maxwell et al., 2015; Clare et al., 2017). Yet, in practice, we know very little about the relationship between objective and subjective forms of resilience measurement.

In this paper, we address this gap in knowledge by comparing objective and subjective measures of resilience using a regionally-representative survey in Northern Uganda. To do so, we introduce a new subjective approach, termed the Subjective

self-Evaluated Resilience Score (SERS). SERS asks respondents to self-evaluate their own household via a series of nine capacity-related questions. We use this module to make like-for-like comparisons between SERS and an objective measure, the Resilience Index Measurement Analysis (RIMA).

Data from the survey are used to examine three research questions. Firstly, given that each household in the survey is assigned both SERS and RIMA modules, we look at how subjective and objective-measures of resilience compare. Secondly, we take advantage of the wide range of livelihood information collected during the survey to examine whether SERS is associated with the same socio-economic drivers and indicators as RIMA. Our last research question looks at the properties of our subjective module in more detail. Specifically, we are interested in knowing whether different variants of SERS produce similar resilience outcomes.

In answering these three queries we stress that neither SERS nor RIMA are 'true' measures a household's resilience. Given that resilience is not directly observable (DFID, 2015), they offer two different ways of inferring resilience outcomes. Yet, considerable value can still be taken in examining how the properties of the two compare. This is especially relevant in testing assumptions that underlie selection of characteristics and indicators for resilience measurement.

We structure our paper as follows. We start by providing background information on resilience and ways of measuring it. We also clarify distinctions between subjective and objective forms of measurement. In the following section we detail our methods, including the properties of the survey as well as the SERS and RIMA modules used within it. We then present results, followed by a discussion structured around the paper's three primary research areas. We finish with a brief description of limitations and ways forward for the resilience measurement community of practice.

2. Background and context

The notion of resilience has a long history spanning multiple academic disciplines (Alexander, 2013). In recent decades, the term has gained prominence across the sustainability sciences in describing how socio-ecological systems respond to shocks and stresses. The rise in popularity has coincided with the adoption of resilience as a unifying framework in bridging humanitarian and development practices. Indeed, resilience is now central to a number of international policy commitments, including the UN's Agenda 2030 and Paris Agreement on climate change (United Nations, 2015a, 2015b). While its prevalence has helped to raise awareness for risk reduction, it has also contributed to considerable debate and confusion around the term's actual meaning.

Historical applications of resilience (mainly those stemming from engineering and ecology) have long been associated with the ability of a system to return to a normalised state after disturbance or change (Holling, 1973; Walker, Ludwig, Holling, & Peterman, 1981). This clearly has many parallels for social systems. However, social scientists were quick to highlight the importance of unique processes such as adaptation and transformation in allowing societies to respond to threats like climate change or environmental degradation (Pelling, 2010; Miller, 2010). In many ways, these can be seen as at odds with notions of resilience as bouncing-back, further contributing to conceptual ambiguity (Olsson, Jerneck, Thoren, Persson, & O'Byrne, 2015).

Discrepancies like these have considerable implications for measurement efforts. Given that resilience cannot be directly observed, most measurement approaches choose to break resilience down in its constituent characteristics (DFID, 2016; Bahadur & Pichon, 2017). Whichever mix of characteristics the evaluator chooses to assign is therefore likely to play a large role in dictating

¹ Subjectively-oriented questions should allow for respondents to internally consider and validate their own understanding of resilience, with outcomes feeding into a quantitative measure.

measurement outcomes: and partly responsible for the vast number of different resilience tools that have emerged in recent years (Schipper & Langston, 2015). To make matters harder, resilience-related characteristics are seldom observable in themselves (Brooks et al., 2019). In the case of objectively-evaluated frameworks, tools often address this challenge by resorting to large lists of proxy-indicators tied to socio-economic traits or other development outcomes (see HSSAI, 2015; Bahadur & Pichon, 2017 for a review of different approaches).

With the above in mind, we focus our analysis on a narrow definition and application of resilience. Specifically, we hone in on a particular unit of analysis: the household. This is due to the centrality of the household unit in dictating responses to external stimuli whether at the individual, family or community-levels (Toole, Klocker, & Head, 2016). Indeed, many of the assets, capabilities and functions commonly assumed to support resilience in social systems derive from, and are dictated by, household-level dynamics (Frankenberger & McCaston, 1998). A focus on households also allows for distinctions to be drawn between psychological resilience – associated with the ability of an individual's psyche to deal with shock or trauma – and the resilience of the individual or household overall. This point is particularly relevant when assigning modules on subjectively-measured resilience (Windle, Bennett, & Noyes, 2011).

Before any effort at measuring resilience can start, one question has to be clarified: resilience to what? Resilience can be defined in relation to a specific hazard or a related set of hazards (Brooks et al., 2019). Here, the literature is replete with examples, including flood resilience (O'Sullivan et al. 2012); drought resilience (Keil, Zeller, Wida, Sanim, & Birner, 2008); or climate resilience (Tyler & Moench, 2012). Conceptually, the idea is to examine the ability of a given system (in our case a household) to cope with and respond to a particular hazard. However, hazards rarely occur in isolation. Households often have to contend with exposure to multiple overlapping risks (O'Brien & Leichenko, 2000; Kelman, 2010; Zobel & Khansa, 2011). As such, resilience is increasingly referred to in relation to broader systemic risk or outcome-related traits – such as disaster resilience (Cutter, Burton, & Emrich, 2010), food systems resilience (Pingali et al., 2005) or economic resilience (Rose, 2004). Here, resilience is thought of as the ability of a system to maintain wellbeing outcomes in the face of diverse multi-hazard environments, many of which may interact in threatening a household's basic functions:

'Climate change, globalization, poverty, earthquakes, injustice, tropical cyclones, lack of livelihood opportunities, inequity, landslides, overexploitation of natural resources, epidemics, and lack of water supply—amongst many other ongoing challenges—often converge to most affect those who have the fewest options and resources for dealing with those challenges. Consequently, those with the fewest options and resources tend to be most vulnerable across all forms of threats, demonstrating multiple exposure to multiple threats simultaneously' Kelman et al. (2010:23)

In the context of this study our focus is on Karamoja, Northern Uganda. More so than any environment, Karamoja is one facing a wide range of overlapping threats: a confluence of colonial subjugation, regional and tribal isolation, and a harsh natural environment (Levine, 2010). Accordingly, we concentrate our analysis on a broader multi-risk conceptualisation of resilience. Yet, we recognise the importance of single-hazard approaches, and seek to compare our main results with these where-ever relevant (see Robustness checks below).

Another important point of clarity relates to the distinction between objectivity and subjectivity. For the purposes of this paper we make use of the objectivity-subjectivity continuum proposed

by Jones (2018). The continuum refers to objectivity and subjectivity in resilience measurement according to two key tenants. The first is how resilience is defined. Objective definitions of resilience can be classed as those externally derived. In practice, this means that resilience is not determined by the people or system being assessed. Rather, the characteristics (or indicators) used to evaluate resilience are drawn from the wider academic literature or through use of extensive expert consultation (Schipper & Langston, 2015). Objective characterisations also tend to be standardised and fixed in their depiction of resilience and its properties (Jones, 2019). On the other side of the continuum, subjective measurement tools draw primarily on the judgement of those being measured themselves. This means that individuals (or a collection of individuals) are responsible for defining what resilience means to them and properties that make up a resilience person or system. These inputs are then used to guide the measurement approach that follows.

The second tenant of the objectivity-subjectivity continuum relates to measurement. Objective approaches to resilience rely on external observations and verification, i.e. little to no room for the judgement and perspectives of those being measured. For example, use of satellite imagery to evaluate the extent of damage to a property, or an assessment of household assets through a household survey can both be seen as objective measures. They involve little, if any, subjective judgement on the part the respondent. On the other hand, subjective assessments make use of people's perceptions in the measurement process itself. They typically involve asking respondents to self-evaluate themselves, drawing on their own internal judgement of their household's ability to deal with risk. The same approach is often used in evaluating subjective wellbeing, where people are asked to self-assess levels of life satisfaction or happiness (OECD, 2013; Dolan & Metcalfe, 2012).

The advantage of portraying this relationship as a continuum is that it highlights that many aspects of measurement fall somewhere in between the two ends of the spectrum. Indeed, few measurement approaches are entirely subjective or objective in nature: choice of objective indicators is often informed by bottom-up community consultations and piloting; subjective-evaluations are often worded and grouped according to objectively-defined definitions of resilience (Jones, 2019). As such, we are careful to make distinctions between the two categories of definition and measurement when referring to the properties of the objective and subjective measures used in our survey.

3. A survey comparing objective and subjective-measures of resilience

In order to shed light on the relationship between objective and subjectively-evaluated resilience, we carry out a representative survey of 2380 households in the Karamoja region of Northern Uganda. We assign separate RIMA and SERS modules to each household allowing like-for-like comparisons of both approaches. Below we provide further detail on how RIMA and SERS scores are computed, as well as the survey methods used to inform our analysis.

a) RIMA: an objectively-evaluated resilience module

The body of objective measures for resilience measurement is large and ever-growing (Schipper & Langston, 2015; Bahadur & Pichon, 2017). Amongst them, one of the most commonly applied quantitative measures is the Resilience Index Measurement Analysis (RIMA). RIMA is developed by the United Nations Food and Agriculture Organisation (FAO) and has undergone a number of iterations since its development by Alinovi, Mane, and Romano

(2008) as an econometric model for estimating household-level resilience to food security. Its latest iteration, RIMA-II, comprises a multi-dimensional objective index devised through Structure Equation Modelling (SEM) and designed to be flexible in relating to outcomes aside from food security (FAO, 2016).

In terms of how RIMA-II conceptualises resilience, the approach acknowledges frameworks supported by the Technical Working Group on Resilience Measurement (FSIN, 2014) and unpacks resilience into four “pillars”:

- (1) **Access to basic services:** a household's access to enabling institutional and public services environments. It includes indicators like health facilities; education; credits; water; toilet;
- (2) **Assets:** income and non-income related assets that enable a household to make a living. It includes both productive (land; livestock; and other income generating activities); and non-productive assets (like households; and other durable goods).
- (3) **Social safety nets:** the network upon which a household can rely when and if faced with a shock. It includes both formal and informal transfers; the social network of solidarity; and reliance.
- (4) **Adaptive capacity:** a “household's ability to adapt to the changing environment in which it operates” (FAO, 2016, p. 14). It includes factors such as education; number of income sources; and reliability of income.

Each pillar is considered a latent variable and is in turn made up of range of proxy socio-economic indicators gathered using household survey data (see Table 1).

In its most commonly used format, RIMA-II is estimated via a two-step procedure. First, a factor analysis is performed with indicators for the four RIMA pillars. Second, a Resilience Capacity Index is devised using the output of the factor analysis by means of a Multiple Indicators Multiple Causes (MIMIC) model – a type of structural equation model (SEM). The MIMIC model is comprised of both the SEM (where observed variables are considered causes of resilience as latent variables) and the measurement model (where the observed variables are considered indicators of resilience). The latter requires a reference unit: a variable assumed to be affected by a household's resilience, commonly associated with wellbeing-related metrics. Given the mandate of FAO, the chosen outcome is typically food security – often equated as combination of monthly per capita food expenditure and dietary diversity. The process allows for a single unit of resilience to be created for a household along a scale of 0 (lowest resilience) to 1 (highest resilience) using a min-max normalisation procedure. An annotated diagram of processes employed in devising the RIMA-II score is represented in Supplementary Fig. 1. For full details of the procedure see FAO (2016) and D'Errico, Grazioli, and Pietrelli (2017).

Table 1
Pillars of RIMA's resilience capacities and the proxy variables used to represent them.

RIMA pillar	Indicators
Access to Basic Services	Household characteristics; Distance to health clinic; Distance to public transportation; Distance to markets; Access to potable water
Assets	Wealth index; Cultivated land value per capita; Tropical Livestock Units (TLU) per capita; Agricultural inputs
Social Safety Nets	Cash transfers per capita; In-kind transfers per capita
Adaptive Capacity	Levels of education; Number of income-generating activities in the household; Dependency ratio (active/non-active members)

Source: FAO, (2016); D'Errico et al. (2017).

For the purposes of this paper, we also introduce an alternative specification of the RIMA-II model. This hybrid model – which we refer to henceforth as ‘RIMA’ – removes the score's tie to a food security outcome. The main advantage of this new model is that it better reflects resilience to broader livelihood outcomes (i.e. overall resilience), rather than their ability to solely maintain food security outcomes (the focus of the original RIMA-II model). As such, this hybrid RIMA is better suited for comparison with the SERS model which is similarly focused on a multi-hazard view of resilience. We therefore consider it our preferred specification for the paper's main analyses. However, we also recognize the well-established use and track-record of the RIMA-II method and run parallel analyses comparing SERS with the original RIMA-II approach too (see Section 4a Testing assumptions).

Our hybrid RIMA measure follows the same initial steps as the original RIMA-II and is based on the conceptual premises outlined in the RIMA-II's guidelines (see FAO, 2016; D'Errico et al., 2017). It uses the same four pillars of resilience, and includes all of the indicators used in RIMA-II. The only difference is that it does not include the measurement part of the structural equation model. Instead it adopts a basic structural equation model to estimate the latent variable that is defined as the co-ordinated result of the four key pillars of resilience. As per the original RIMA-II approach, RIMA scores are normalised on a scale of 0–1.

b) SERS: a subjectively-evaluated resilience module

For the subjective module of our survey we use the Subjectively self-Evaluated Resilience Score (henceforth referred to as SERS). Similar to RIMA, SERS considers resilience to be made up of a range of resilience-related capacities. The module is adapted from a hazard-specific variant proposed by Jones, Samman, and Vinck (2018) and features a total of nine resilience-related capacities and capitals chosen on the basis of an extensive review of available literature (see Table 2). Each resilience-related capacity is then adapted to self-elicited questions, with respondents asked to rate their levels of agreement ranging from strongly agree to strongly disagree. Pilot exercises of the module were also carried out in a nationally representative survey of Kenya (early 2017) and regional surveys in Hpa An, Myanmar (Jones, 2017).

Subjectivity is at the core of the SERS approach. However, it is important to note that by prescribing a set of resilience-related characteristics, SERS falls under the category of objectively-defined (i.e. the characteristics are selected from a review of the wider resilience literature, rather than those being measured themselves). The distinction highlights the non-binary nature of objectivity and subjectivity, and that most approaches will have elements of both. It also draws attention to the advantage of thinking of the relationship between the two along an objectivity-subjectivity continuum as described in Jones (2018). Respondents are asked to score their level of agreement with each capacity using a Likert scale with 5 response items (Strongly disagree = 1, Strong agree = 5). While numerical conversion of Likert scale responses of this type is typical across the social sciences, it is important to recognise that assumptions of cardinal comparability are disputed (Kristoffersen, 2017).

Each characteristic can either be compared individually or aggregated together to form a single collective score comprising multiple capacities. Together this aggregate score constitutes the household's resilience outcome, acting as a rough marker of overall resilience. A Cronbach's Alpha score of 0.79 suggests high internal consistency across the nine resilience-capacities. To ensure computational ease and transparency, we numerically convert answers for each of the resilience-related capacity questions and calculate an equally-weighted average mean score. As with the RIMA output, subjectively-evaluated resilience scores are normalised on a scale

Table 2

List of nine resilience-related capacity questions used in the SERS module.

Resilience-related capacity	Question	References
Absorptive capacity	Your household can bounce back from any challenge that life throws at it	Béné, Wood, Newsham, and Davies (2012) Bahadur et al. (2015)
Transformative capacity ¹	During times of hardship, your household can change its primary income or source of livelihood if needed	Béné et al. (2012) Kates et al. (2012)
Adaptive capacity	If threats to your household became more frequent and intense, you would still find a way to get by	Jones, Ludi, and Levine (2010) Béné et al. (2012) Bahadur et al. (2015)
Financial capital	During times of hardship, your household can access the financial support you need	Mayunga (2007) Birkmann (2006)
Social capital	Your household can rely on the support of family and friends when you need help	Cox and Perry (2011) Aldridge (2012) Sherrieb, Norris, and Galea (2010)
Political capital	Your household can rely on the support politicians and government when you need help	Birkmann (2006) Magis (2010) Renschler et al. (2010)
Learning	Your household has learned important lessons from past hardships that will help you better prepare for future threats	Folke et al. (2002) Cutter et al. (2008) O'Brien, O'Keefe, Gadema, and Swords (2010)
Anticipatory capacity	Your household is fully prepared for any future natural disasters that may occur in your area	Paton (2003) Foster (2007) Bahadur et al. (2015)
Early warning	Your household receives useful information warning you about future risks in advance	Thywissen (2006); Twigg (2009) Aldridge (2012)

¹ The definition of transformation used here is largely based around the ability of a household to modify livelihood activities when and if required – see Béné et al. (2012) and Kates et al. (2012) for more.

of 0–1 using min-max normalisation (higher scores indication higher resilience). While this score is neither exhaustive nor holistic in measuring a respondent's subjectively-evaluated resilience, it does provide a useful starting guide. As a robustness check, we also devise a score using an alternative weighting procedure derived from a Principal Component Analysis (PCA). As overall results appear to be almost identical between the simple averaging and PCA, we present results from the equal-weighted score in this paper (see Section 4a Testing assumptions, and [Supplementary Tables 2 and 5](#)).

SERS is designed to be flexible with regards to different definitions and characterisations of resilience. As such, it allows evaluators to pick and choose any number of combinations of different resilience-related capacities. In this paper, our main model uses all 9 resilience-related capacities based on the approach used by Jones (2018). However, we also look at different variants of SERS based on widely used frameworks in the resilience literature. The first is a subset of three resilience-capacities comprising Absorptive, Adaptive and Transformative capacities named the SERS-AAT variant. This combination of capacities has been widely applied within the resilience literature (Pelling, 2010; Béné, Wood, Newsham, & Davies, 2012) as well as shaping resilience-building programmes – see Oxfam's Framework for resilient development (Jeans, Castillo, & Thomas, 2017). On one hand it builds on early socio-ecological concepts of resilience, highlight the ability of system to maintain core functions in response to threats (Holling, 1973; Walker et al., 1981). On the other, it acknowledges the

importance of adaption, and in some cases transformation, to allow systems to deal with evolving risk (Kates, Travis, & Wilbanks, 2012).

A second variant uses another subset of three capacities made up of anticipatory, absorptive and adaptive capacities named the SERS-3A variant. This mimics the 3A's framework first proposed by Bahadur et al. (2015) and used by the BRACED programme as well as range of other assessments (Wilson & Yarron, 2016; Bottazzi et al., 2018). This framework is similar to the AAT model, adding particular weight to the importance of anticipatory mechanisms, such as early warning systems and disaster risk reduction activities (in place of transformation) (Thomalla & Larsen, 2010).

Lastly, as noted in [Section 2](#), we focus our SERS module on a multi-hazard view of resilience. As such, SERS questions make no reference to individual hazards. Instead we refer generically to 'threats', 'challenges' or 'disasters'. Doing so is also important in minimising the likelihood of priming effects amongst respondents (OECD, 2013). However, we recognise that specifying resilience to single hazards can also be of benefit to practitioners – particularly in cases where interventions targeted a single hazard. Accordingly, we also include a hazard-specific SERS module mimicking the example used by Jones et al. (2018) focused on drought risk – the primary threat facing livelihoods in Karamoja (see [Supplementary Table 1](#) for wording).

Inherently the questions used in the SERS module cannot cover all aspects of resilience, nor do they seek to. Rather, they give a useful indication of a subset of capacities that are known to strongly influence a household's resilience. In addition, while each capacity is considered distinct in its own right, it is important to note that some degree of overlap is inherent, limiting the extent to which the unique contributions of each can be isolated. For example, close ties exist between adaptive and transformative capacities, as both relate to processes of structural change (Few, Morchain, Spear, Mensah, & Bendapudi, 2017). Yet, these are often referred to separately within the resilience literature (Pelling, 2010; Kates et al., 2010). As outlined above, different subsets of the SERS module can also be constructed to account for preferences in conceptualising resilience.

Finally, we note that attempts to quantify people's own assessments of resilience may not be altogether obvious. Subjective insights on resilience have been gathered extensively through qualitative means, recognising the richness and nuance that these methods provide (Ayeb-Karlsson, van der Geest, Ahmed, Huq, & Warner, 2016; Maxwell et al., 2015). SERS is by no means an attempt to replace the importance of qualitative contributions to our understanding of resilience through interviews, focus groups and immersive research methods. Rather, it seeks to complement it. It is a way of translating bottom-up subjective judgements into a quantifiable metric that can be readily compared, and potentially combined, with traditional objective approaches. In doing so, it answers recent calls for plurality of research methods in understanding resilience:

'Resilience measurement requires multiple method assessment approaches that capture perceptions, opinions, judgments and the nature of social interactions as well as the observable or easily measureable characteristics of social ecological systems'. Maxwell et al. (2015:4)

c) Data

To test the relationship between objective and subjectively evaluated resilience we make use of a household survey conducted in Karamoja, Uganda in 2016 by FAO. The purpose of the survey was twofold: to understand the resilience capacities of communities in Karamoja; and to determine baseline values for an impact

evaluation of ongoing interventions under the Joint Resilience Strategy (JRS)².

The survey is composed of a total of 2380 households. The sampling strategy is stratified according to the five strata: (1) target households, which are those reached by the JRS in 12 parishes of the Moroto and Napak districts; (2) direct spillover households, which are those located in the remaining parishes of the Moroto and Napak districts and are not involved in the JRS; (3) indirect spillover households, which are those located in the two districts where the JRS does not operate (Kotido and Nakapiripirit) but where other UN projects are ongoing; (4) a 'different ethnicity' group, which includes households located in two districts (Abim and Amudat) populated with ethnic groups that are different from the Karamojong (the principle ethnic group in the region); (5) and the pure control group, comprised of households located in the Kaabong district, which have the same ethnic group and socio-economic conditions, mostly pastoralism, as the target group, but which are not involved in the JRS.

The household questionnaire is comprised of a range of thematic sections and piloted in Moroto in November 2016. Specifically, it collects detailed information on household characteristics, including food and non-food consumption, shocks, coping strategies, and so on. Much of the socio-economic data was then used to compile the RIMA indexes, and compared with subjective measures of household resilience. Results from the survey are shown below.

4. Results

The first research question that we explore is whether our objectively-evaluated (RIMA) and subjectively-evaluated (SERS) modules are correlated. Fig. 1 shows a series of different associations and traits comparing RIMA and SERS outcomes. The first thing to note is that the distribution of scores is far narrower for RIMA ($s = 0.13$, $\bar{x} = 0.31$) than for SERS ($s = 0.21$, $\bar{x} = 0.49$) (Fig. 1a).

Secondly, the association between RIMA and SERS scores is positive. Fig. 1b shows a count plot of the full range of resilience scores, while Fig. 1c-d show mean SERS scores for aggregated RIMA values. While the raw values are somewhat scattered ($R^2 = 0.25$), a relatively clear linear relationship is apparent not only for the full SERS model, but the SERS-3A as well. Values do not line up 1:1, with SERS tracking slightly higher for low RIMA values, and slightly lower for high RIMA values.

We are also interested in comparing associations between our resilience modules and key socio-economic drivers of household resilience. For example, much of the literature cites the accumulation of asset wealth as a strong determinant of a household's ability to deal with disturbance (Tyler & Moench, 2012; Cutter et al., 2008). Interestingly, both RIMA and SERS modules demonstrate positive relationships (as shown in Fig. 2a), with higher wealth accumulation corresponding to higher levels of resilience. Similar positive associations are apparent for diversity of incomes sources as well as food security (represented by the CSI index³), both traditionally considered as core drivers of resilience at the household level (Adger, 1999; Jabeen, Johnson, & Allen, 2010). Not all assumed associations overlap however. For example, while the highest level of

education for household heads shows a marked positive association under RIMA, no such association is apparent for the SERS module⁴.

While descriptive and univariate analysis is useful in uncovering broad associations, it is also important to account for the effects of any confounding factors before drawing firm conclusions. To do so we run a series of OLS regression models with SERS and RIMA as our two dependent variables. A range of socio-economic traits – each considered to have a degree of association with resilience within the resilience literature – are gathered from the remainder of the survey modules and serve as independent variables within the models. Both models include area fixed effects with standard errors clustered at the sub-county level. In comparing a range of different setups, we also look at outcomes from regressions models using simple Ordinary Least Squares (OLS) with area fixed effects removed, area-fixed effects with robust standard errors and multi-level models with households nested within sub-counties and districts – see Robustness Checks.

$$SERS_{hc} = \alpha_c + \beta_1 SHOCK_{hc} + \beta_2 DRIVER_{hc} + e_{hc} \quad (1)$$

The primary OLS set up with area-fixed effects is presented in Eq. (1). Here the outcome $SERS_{9C_{hc}}$ relates to the 9C variant of the SERS model indexing households h in sub-county c . $SHOCK_{hc}$ is a vector of dummy variables for a series of self-reported shocks, these include drought, flood, crop disease and illness. $DRIVER_{hc}$ is a vector of socio-economic variables commonly associated with drivers of household resilience. α_c is shown as a sub-county fixed effect (expressed as dummies) with the error term represented by e_{hc} .

Outputs from the above are compared directly with Eq. (2). This model shares an identical structure to that of Eq. (1), simply replacing RIMA, through $RIMA_{hc}$, as the outcome variable of interest.

$$RIMA_{hc} = \alpha_c + \beta_1 SHOCK_{hc} + \beta_2 DRIVER_{hc} + e_{hc} \quad (2)$$

In effect, outputs from Eq. (2) are somewhat uninteresting in isolation: results simply inform us of the assumptions and weights assigned to various indicators that feed into the RIMA model. Instead, real utility comes from side-by-side comparisons of Eqs. (1) and (2).

Given that the SERS approach does not factor any of the shocks or input variables when asking people to self-evaluate, a comparison of the two models serves as a quasi-independent check of the RIMA set-up and indicators used within. In theory, if both scores are wholly reflective of the same underlying property (and are void of bias), then we would expect similar trends and effects from the variables of interest. Though in practice it may be difficult to argue that RIMA and SERS are capturing an identical latent construct (i.e. overall household resilience), they undeniably overlap and should be expected to broadly reflect the same associations with relevant drivers of resilience.

Fig. 3 presents side-by-side comparisons of outputs from the RIMA and SERS models. Variables above the dashed horizontal line share the same sign of association for both models (i.e. a positive or a negative association on resilience), those below have opposing signs. For ease of viewing and interpretation, variables are ordered in relation to the highest and lowest coefficients in the RIMA model (essentially showing us the magnitude of relative weightings used in the RIMA set up). Given the potential for non-linear relationships we also include quadratic terms for each of the socio-economic drivers (see Supplementary Table 7). Again many associations are matched between the two approaches – though there are some differences between linear and non-linear relationships (notably wealth and CSI).

⁴ We return to the relationship between education and resilience in more depth in Section 5a.

² For more information on the types of activities supported under the JRS and its evaluation see <http://www.fao.org/3/ca0345en/CA0345EN.pdf>. A follow-up survey is scheduled to take place by 2020 resulting in a panel dataset.

³ CSI is an indicator of household food security that uses a series of questions about how households manage to cope with a shortfall in food for consumption results in a simple numeric score. In its simplest form, monitoring changes in the CSI score indicates whether household food security status is declining or improving (see Maxwell, Watkins, Wheeler, & Collins, 2003).

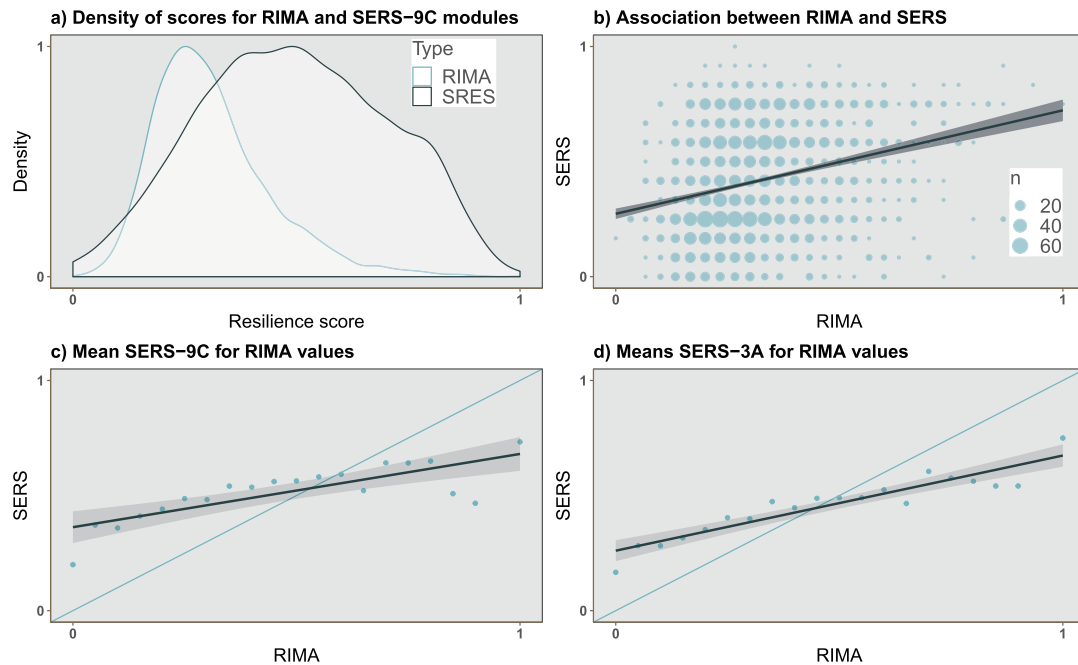


Fig. 1. Densities and relationships between RIMA and SERS variants. Notes: Panel a shows probability densities of our hybrid RIMA model alongside the SERS (9C variant). Panel b features associations between raw SERS scores and RIMA values rounded to match the same number of permissible response items (33). Panels b, c, and d feature mean SERS scores for aggregated RIMA values rounded to the nearest 0.1.

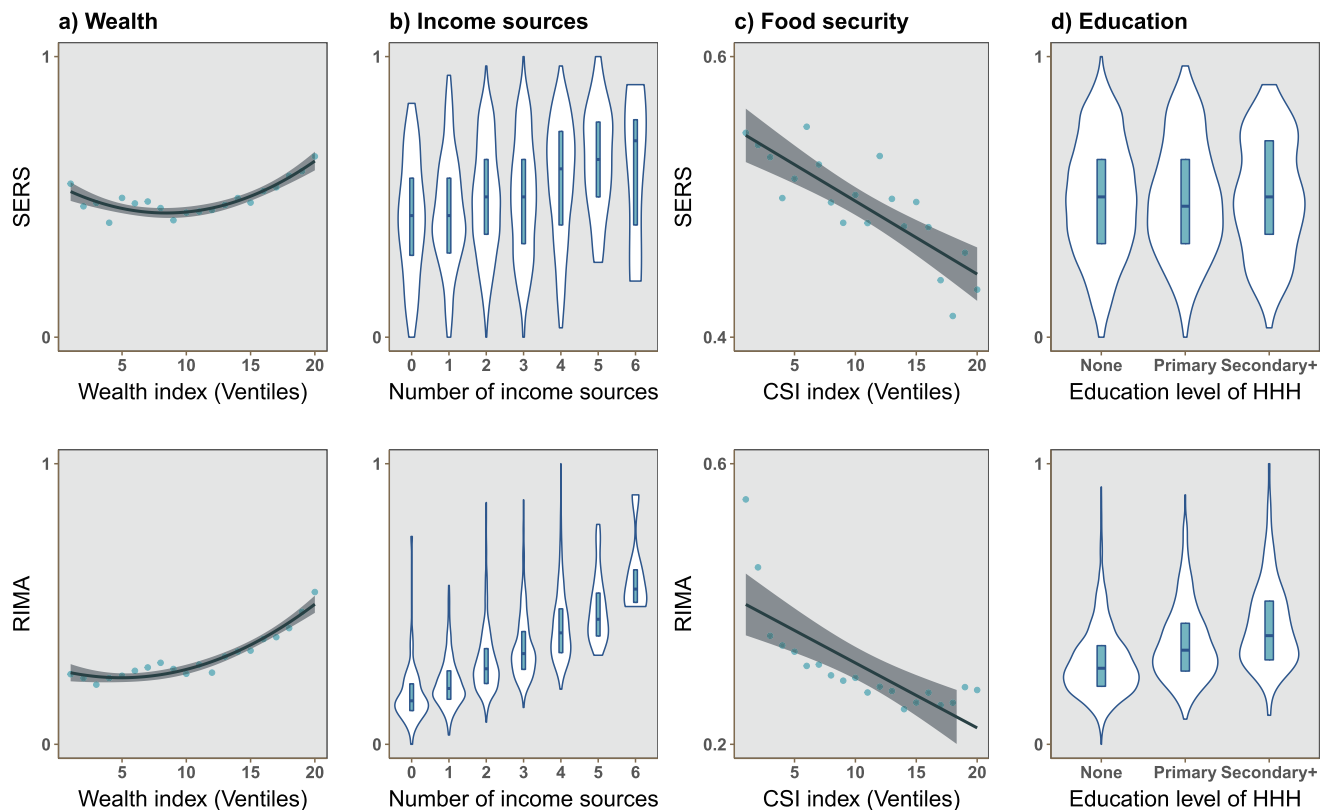


Fig. 2. Relationships between objective and subjectively-evaluated modules and key socio-economic variables. Notes: Panels a) and c) feature mean SERS and RIMA scores across binned ventiles. Plots b) and d) feature violin plots with a boxplot (median and first/third quartiles) in the centre and kernel probability densities along the outside.

Another way to compare our two resilience modules is to see whether the individual characteristics of RIMA's resilience model are associated with people's self-assessed scores. RIMA breaks resi-

lience down into four core characteristics: adaptive capacity; assets; social safety nets; and access to basic services. To examine the extent to which these characteristics are reflected in people's

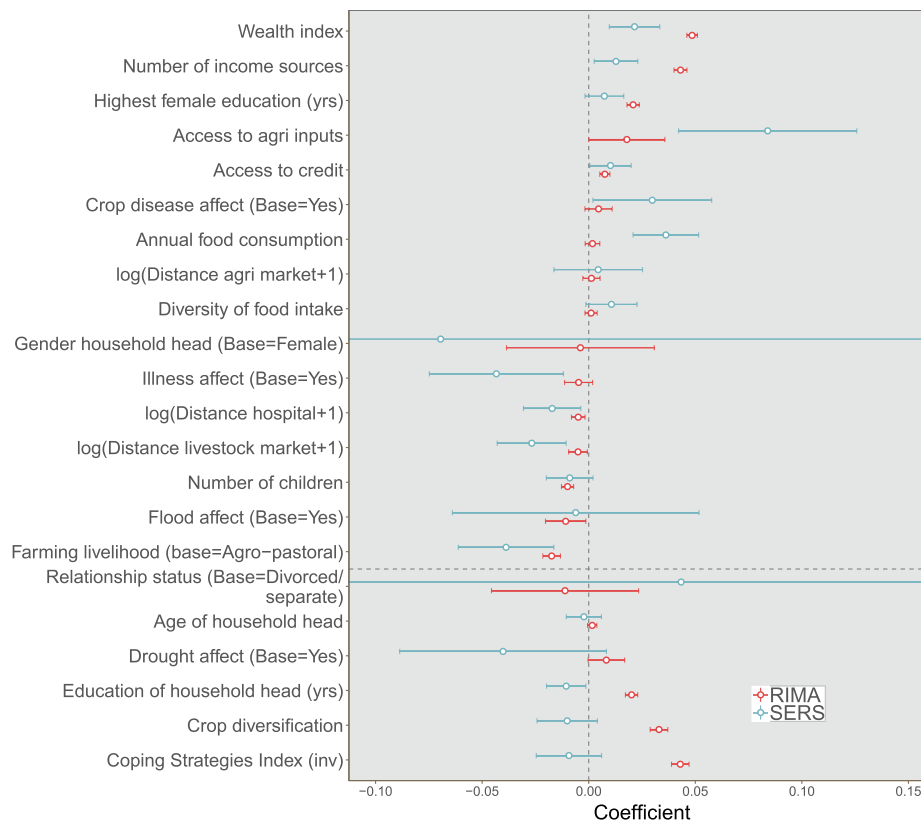


Fig. 3. Coefficient plot comparing associations with socio-economic drivers of resilience for RIMA and SERS. Notes: Dots represent standardised beta coefficients, 95% confidence intervals are represented as whiskers. Whiskers for Gender and Relationship status variables under the SERS model have been cut-off for ease of comparative viewing. Standard errors are clustered at sub-county level. The horizontal dashed line represents variables that disagree in sign between RIMA and SERS models (those above agree in sign, those below do not). Variables are ordered in relation to highest-lowest coefficients for the RIMA model (the opposite is the case for variables below the dashed horizontal line).

self-assessments we run an OLS model (Eq. (3)) with SERS as the outcome variable, $SERS_{hc}$. As with prior models, we include area-fixed effects and cluster standard errors at the sub-county level. Under this specification each of RIMA's four characteristics⁵ are represented by AST_{hc} (assets), ABS_{hc} (access to basic services), SSN_{hc} (social safety nets) and AC_{hc} (adaptive capacity) – see FAO (2016) and D'Errico et al. (2017) for a full list of indicators associated with each pillar.

$$SERS_{hc} = \alpha_c + \beta_1 AST_{hc} + \beta_2 ABS_{hc} + \beta_3 SSN_{hc} + \beta_4 AC_{hc} + e_{hc} \quad (3)$$

Outputs from Eq. (3) are compared directly with a parallel model that places RIMA scores, $RIMA_{hc}$, as the outcome variable. Indeed, given that the indicators used in compiling RIMA's four pillars are largely independent of the SERS set-up it can loosely be considered as an independent check.

$$RIMA_{hc} = \alpha_c + \beta_1 AST_{hc} + \beta_2 ABS_{hc} + \beta_3 SSN_{hc} + \beta_4 AC_{hc} + e_{hc} \quad (4)$$

Again, Eq. (4) on its own is not particularly informative. It demonstrates the weightings assigned to each of four characteristics of resilience as specified within the RIMA model (and hence why the confidence intervals are far smaller for RIMA compared with SERS outcomes). However, when comparing the Eqs. (3) and (4) together we see that all four characteristics are positively associated with SERS (Fig. 4). Assets have the largest marginal effect with social safety nets the lowest. It is also worth noting that the effect sizes for anticipatory capacity and assets are far higher for the RIMA model compared with SERS. While this may imply that

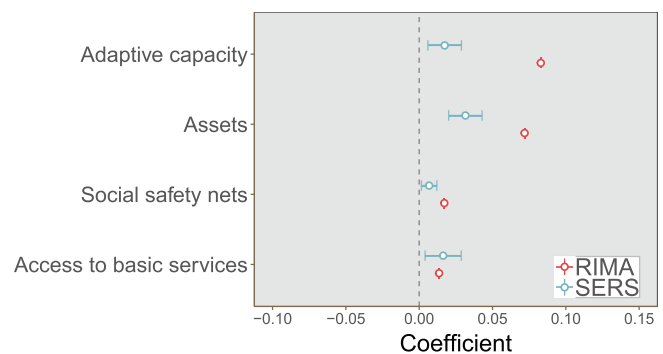


Fig. 4. Coefficient plots showing associations between RIMA (blue) and SERS (red) relative to RIMA's four characteristics of resilience. Notes: Dots represent standardised beta coefficients, 95% confidence intervals are represented as whiskers. Standard errors are clustered at sub-county level. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

RIMA is overweighting, it's important to consider that self-assessments have a far wider range of potential influencing factors when compared with RIMA's four characteristics.

The paper's final research query seeks to compare outcomes of different versions of the SERS approach. As is clear from Fig. 5a, strong overlaps exist between the 9C and 3A variants of the SERS model, with both closely tracking a 1:1 ratio. A similar association is also apparent when comparing 9C and AAT variants in Fig. 5b. While values are more scattered, comparison of the 3A model of overall resilience with the 3A hazard-specific variant also demonstrates a high degree of overlap.

⁵ Note that FAO use the term 'pillars' rather than characteristics

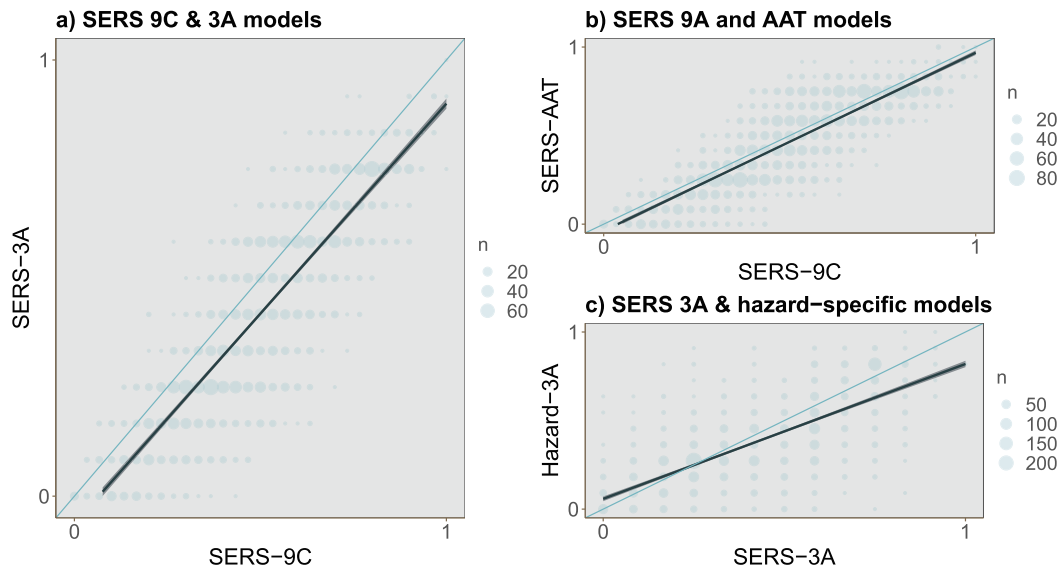


Fig. 5. Count plots of relationship between different variants of self-evaluated resilience. The size of dots represents the frequency of responses with the same score. Note that all models in figures a) and b) are in relation to overall resilience, figure c) compares a model of overall resilience with a hazard-specific model.

Fig. 6a shows that correlation coefficients between SERS variants are high. By way of an interesting point of comparison, the relationship between the original RIMA-II specification (the variant of RIMA that is tagged specifically to a food security outcome) and our hybrid version of RIMA (which has no outcome variable and is therefore a better reflection of overall resilience) is notably weaker with an R^2 of 0.48.

We can also look at correlations between the various resilience-related capacities that contribute to SERS. Fig. 6b highlights a wide range of associations, with the strongest tie appearing to be between Adaptive and Absorptive capacities. To get a more detailed understanding of the links between resilience-related capacities we also run a Principal Component Analysis with all nine capacities in the full SERS module. Supplementary Table 2 confirms that Absorptive and Adaptive capacities are the two strong contributors to the SERS scores, followed by Anticipatory and Transformative capacities. Interestingly, Political capacity appears to have

consistently low correlations with other resilience-related capacities, with slight loadings in the first principal component. As such, its use is dropped as part of the SERS-PCA variant, weighted on the basis of the first principal component across all nine-capacities (see Supplementary Table 2).

While different subjective variants appear to be highly correlated, what about similarities between underlying socio-economic drivers? As with the analysis above we perform a series of OLS regressions that allow for side by side comparisons between the three main variants of the SERS subjectively-evaluated resilience approach. Specifications for these models are identical to Model 1 except that the outcome variable is replaced by the 3A and AAT variants of overall resilience respectively. As apparent from Fig. 6, associations between subjective self-evaluations of resilience and various drivers and shocks remain notably similar across the three variants (see also Supplementary Table 6). Indeed, there are only a small number of variables that do not exhibit the same sign and

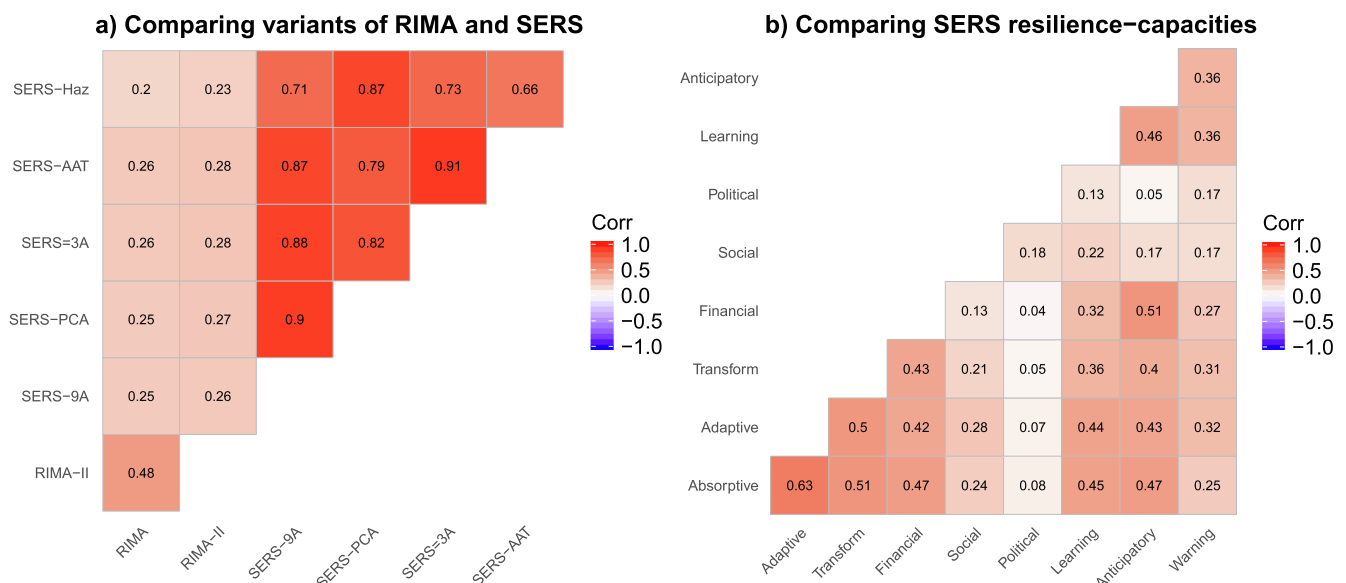


Fig. 6. Correlation matrix of different resilience modules and SERS resilience-capacities. Notes: Correlation plots shows coefficients for various SERS traits with corresponding values matched to colours in the legend. Correlations are presented as Pearson coefficients.

level of statistical significance. Moreover, the two with opposing signs – whether the household has experienced a flood in the past 12 months and relationship status of the bread-winning couple – have such wide confidence intervals that little can be inferred about the differences.

a) Testing assumptions and robustness

In order to test the validity of the paper's findings we perform a number of robustness checks. As mentioned earlier, alongside our preferred model setups we also run alternative specifications to examine the consistency of our results. [Supplementary Table 3](#) shows comparisons of RIMA and SERS when run using OLS with no area-fixed effects (1 and 5), OLS with area fixed effects (2 and 6), OLS with area fixed effects and clustered standard errors (3 and 7, and our preferred model setup) and a multi-level model that nests households within sub-counties and district (4 and 8). All OLS models feature robust standard errors unless otherwise stated. Though there are some apparent differences in the size of standard errors (notably in relation to the effect of crop diseases), all four models appear to be largely consistent.

Another important step taken in our analysis is the use of a modified version of the RIMA approach. The hybrid RIMA model is considered a more suitable comparison with SERS given that it better reflects overall resilience and is no longer tied to a food-security outcome. Yet, we recognise that the original RIMA tool is well established within the literature and often used as a proxy for wider resilience outcomes too (not just food security). Therefore, we run the same model set-ups as before, using the original RIMA-II instead of hybrid version. Results are presented in [Supplementary Table 4](#) with a similar range of regression runs as specified in SM Table 3. Some differences are noted between the two set-ups, though most are unsurprisingly in relation to food-related variables such diversity of food intake, annual food consumption and crop diversification.

A key factor in evaluating survey modules made up of multiple question is weightings. While we use an equally weighted average for most of the results presented in the paper, we also test our results with an alternative version (labelled SERS-PCA) that weights resilience-capacities according to the first principal component (with 8 questions retained). Accordingly, [Supplementary Table 5](#) re-runs comparisons between RIMA and SERS-PCA. Again, we find few differences.

Lastly, we note that a weakness of many subjective measures is a tendency for respondents to agree with all questions, or provide consistently similar answers throughout a survey – known as acquiescence bias (OECD, 2013). To account for this, we remove any household from the sample that provides the same answer across each of the resilience-related capacity questions. When Model 2 is rerun under this set-up we see no qualitative differences (see [Supplementary Table 6](#)).

5. Discussions and conclusion

Results from our Karamoja survey point to a number of interesting findings and discussion points. Below we reflect on our three main research areas, and consider limitations and ways forward for future efforts to define, measure and promote resilience.

a. Comparing objective- and subjectively-evaluated resilience

One of our main findings is that a positive linear relationship exists between the objective (RIMA) and subjectively-evaluated (SERS) modules used in our Karamoja survey. This relationship is clearly highlighted in [Fig. 1c-d](#), with mean SERS scores consistently

rising with higher aggregated RIMA values. The fact that two largely independent approaches appear to point in a similar direction will give some confidence to resilience evaluators. More importantly, the association suggests that, in the case of Northern Uganda, households that are assumed to be resilient (at least from the perspective of FAO's criteria) generally perceive themselves to be resilient as well.

Another point is abundantly clear: the relationship between RIMA and SERS is far from strong. An R^2 of 0.25 suggests that any correlation is moderate at best, and that the two measures should not be used interchangeably. The implications for resilience measurement depend on how the scores are used and compared. From one perspective, comparing raw scores paints a picture of a noisy relationship between subjective and objective-measures ([Fig. 1b](#)); from another, aggregated information shows neat and clear trends ([Fig. 1c-d](#)).

Differences in the distribution of both scores are also marked, with standard deviations (s) of 0.21 and 0.13 for SERS and RIMA respectively. Indeed, it suggests that, from the perspective of people's own judgements, levels of resilience are far more varied than assumed under RIMA. Part of this may reflect the fact that subjective-evaluations place no limits on the wide range of factors that an individual might consider in evaluating their household's resilience – as opposed to RIMA that is constrained to a handful of objective indicators. It may also reflect a diversity of subjective interpretations and judgements on resilience.

With this in mind, it is worth reinstating that neither RIMA nor SERS are direct measures of a household's resilience. They are two different ways of inferring resilience. Understanding which of the two most closely approximates a household's 'true' resilience requires tracking changes in wellbeing outcomes over time – itself subjective to different interpretations and inferences. As such, the value of both measures should be considered equivalently, based on the strengths of methodological assumptions and objectives of the evaluator. Our findings underscore the need for development actors to be mindful of the diversity of knowledge sources for resilience. Care should also be taken in assuming that aggregated resilience outcomes are homogenous across communities and households. Most importantly, as evaluators seek to refine and choose methods for evaluating development practices, it is imperative that the merits and limitations of different methods are made fully transparent.

b. Comparing associations with drivers of household resilience

The second dimension of our study looks at whether objective and subjectively-evaluated approaches share similar associations with key socio-economic drivers of resilience. Like-for-like comparisons in [Figs. 2 and 3](#) show that most of the traits in our model (16/22) share the same sign of influence for both RIMA and SERS. Common significant drivers include: asset-wealth; diversification of income sources; livelihood type; distances to a hospital and livestock market; and access to agricultural inputs and access to credit. Most of these have a rich history of association with resilience amongst the wider resilience literature (Tyler & Moench, 2012; Cutter et al., 2008; Adger, 1999; Jabeen et al., 2010).

Many of the associations make logical and conceptual sense. For example, the importance of wealth and financial capitals is well documented as a driver of resilience, allowing households to accumulate and use assets during times of hardship (Tyler & Moench, 2012; Cutter et al., 2008). The same is true for income diversity, where development practitioners have long promoted diversity as a means of spreading risk (Jabeen et al., 2010). A negative association with distances to hospitals and markets is also reassuring, though it's important to note that both are largely found in urban areas and may be confounded by other unobserved variables.

Interestingly households reliant on farming as their primary source of livelihood appear to have lower scores than agro-pastoralists. This negative relationship may point to the benefits accrued by agro-pastoralists in being able to more easily reallocate assets and livestock in search of more favorable climates during times of drought (or other hardships) (Opiyo, Wasonga, Nyangito, Schilling, & Munang, 2015). The finding is particularly relevant in light of ongoing political and academic debates over tradeoffs between pastoral and settled livelihoods in Karamoja. Indeed, many development actors have historically portrayed nomadic pastoralism as a particularly vulnerable and unviable source of livelihood in the region (Levine, 2010).

Strong overlaps in association suggest that SERS is picking up on many of the same socio-economic drivers and indicators used in deriving the RIMA model. The fact that all four pillars of the RIMA model are positively associated with SERS outcomes further underscores this point (Fig. 4). Common associations are all the more significant as the two modules are largely independent of one another. None of the objective indicators that make up the RIMA model are used in SERS. Aside from potential priming effects, there is nothing to systematically encourage respondents to respond similarly across the two modules – indeed, given the size and complexity of the RIMA survey module this would be a considerable undertaking.

However, our objective and subjectively-evaluated module do not agree on associations amongst all drivers. Indeed, just as much can be learned from disagreements between the two. For a start, effect sizes differ markedly. For example, wealth has the strongest positive association with RIMA (a 0.048 rise for every one standard deviation increase in the wealth index). Yet, its effect on SERS is less than half (a 0.021 rise). The implication here is that while both RIMA and SERS recognise wealth as an important component of resilience, its association is considerably lower when considering people's own self-assessments. Similar patterns are true for other drivers, including diversity of income sources and years of schooling for female household members – both of which have significant positive associations, though with far weaker effects on SERS outcomes.

Interestingly, the converse is also true. A number of traits have far stronger effect sizes for SERS than for RIMA. Most notable are large differences for access to agricultural inputs and livelihood practices, with SERS β values twice those for RIMA. Some drivers are significantly linked with one approach and not the other. For example, food consumption has a significant positive association with RIMA, with a negligible and insignificant role for SERS outcomes. Again, the implication being that the influence on socio-economic drivers of resilience differs from the perspective of expert elicitation (i.e. RIMA) compared with people's own subjective judgements (SERS).

Perhaps the most important finding relates to instances where drivers have opposing signs of influence (those below the grey dotted line in Fig. 3). Here we observe traits that have fundamentally different associations between RIMA and SERS approaches. The largest such difference comes in the form of the Coping Strategies Index, considered a proxy for food insecurity. CSI has a large positive link with RIMA (households that are more food secure have higher RIMA scores). Yet, its association with SERS is not statistically significant. If anything, the sign of influence is slightly negative. [Supplementary Table 7](#) also suggests the relationships may be non-linear, with opposing signs for quadratic terms. We would, however, caution against the blanket conclusion that food security plays a negative (or no) role in people's subjective judgements. Indeed, annual food consumption, diversity of food intake and access to agricultural inputs all have strong positive associations with resilience (far higher than for RIMA in fact). Rather, it highlights that food security is multi-faceted, and that different

elements are likely to interact with resilience in different ways. Our findings may also suggest the need for greater evidence and clarity in the heavy use of CSI as a proxy or food security in weighting objective models.

Another interesting disparity relates to the role of education. Higher education levels of the household head have strong positive associations with RIMA. This is reflected in the wider resilience literature where higher education is linked with individual-level behaviours supportive of resilience and heightened awareness of future risk (Pissello et al., 2017). Yet, surprisingly, we find that education has a slight negative association with SERS. This may again reflect differences in judgement between subjective and objective measures. However, we believe that geography and context may also be playing a strong role here.

Karamoja is an arid landscape frequently affected by drought. Nomadic livelihoods therefore have some advantages as they are able to relocate during times of hardship (Opiyo et al., 2015; Levine, 2010) – this is underscored by the fact that pastoralists have higher SERS scores than farmers. While formal levels of education may benefit households in the area, it is likely to provide little added benefit when compared with local informal and indigenous knowledge gained in coping with persistent drought (particularly once controlling for income or asset wealth). Interestingly, a similar lack of association between subjectively-evaluated resilience and formal education is observed across a number of other subjective assessments by Jones and Samman (2016); Béné et al. (2016); and Claire et al. (2018). Together this suggest that a greater understanding of the links between education and household resilience is needed before strong conclusions can be drawn. More can also be done to distinguish between the roles of formal and informal education in supporting resilience, including how they are reflected in resilience metrics.

Lastly, we consider the role of past shocks. It is commonly assumed that exposure to shock will reduce a household's resilience capacities, as over time repeated shocks wear away at a household's ability to deal with future risk (Silbert & Useche, 2012; Kahn, 2005; Ibarra et al., 2009). However, findings from the Karamoja survey suggest that this relationship may be more nuanced. Households that have not experienced a shock in the last 12 months are associated with lower SERS scores than those that have experienced a shock. This trend runs true across a number of shock types, including droughts, floods and illness (not so for crop diseases).

While the relationships may seem somewhat counterintuitive, there are conceptual and practical grounds to consider it. Households that have experienced a recent shock may be in a better position to not only gain insights into relevant coping strategies, but better anticipate and adapt to future risks using the experiences gained in recovery (Berkes & Turner, 2006). Experiential grounding, with knowledge built up through experience of past shocks to inform more effective future strategies is well documented (Tschakert & Dietrich, 2010). Though we strongly suspect that any such advantages would only accrue in the context of smaller shocks or stresses; it is harder to see how acute threats would be advantageous. Indeed, this may partially explain why crop disease shows an opposing trend, as Karamoja has a long history of devastating locust outbreaks and disease-related threats (Gartrell, 1985) – though this trait is difficult to verify without follow-up research and information.

We also consider that changes in risk perceptions may be a factor, with the wider literature mixed on this issue. Wachinger, Renn, Begg, and Kuhlicke (2013) highlight examples such as Ruin, Gaillard, and Lutoff (2007), Ming-Chou (2008); and Mirceli et al. (2008) that show how direct experience of a natural hazard leads to an overestimation of future risk and a greater sense of dread. Contrastingly, other examples – such as Hall et al. (2009) and

Scolobig, De Marchi, and Borga (2012) – point to prior experience as leading to beliefs that future events are unlikely to affect people and thus lower risk perception. Given the consistency of negative associations for SERS across a range of shocks, we see sufficient grounds to challenge many objective approaches (including RIMA) in being explicit in their justification of assumed links between prior shocks and resilience.

Above all, our findings point to the importance of recognising different sources of knowledge on resilience. The fact that associations with many socio-economic drivers overlap between SERS and RIMA is certainly encouraging. Again, it suggests that both modules are picking up on similar underlying properties. However, the extent (and in some cases the sign) of some associations clearly differ between objective and subjectively-evaluated modules. In such instances, it is important for evaluators to rigorously examine the evidence base for key assumptions. It also calls for a plurality of knowledge sources to be considered. This is particularly relevant for picking indicators that feed into objective measures.

c. Different variants of the SERS subjective approach point in the same direction

Our final research question looks at how different variants of the SERS module compare. Fig. 5 shows that all three variants (3A, AAT and 9C) of the SERS model are highly correlated. The same is also true in comparing versions of SERS that focus on hazard-specific and overall resilience (see Fig. 6). We believe that these traits have important implications for how resilience is characterised. To date, resilience can (and has) been chopped up in myriad ways (as alluded to in Section 2). In fact, considerable time is spent arguing over the right mix of capacities constituting a resilient social system: whether adaptation is needed to recognise evolving risks (Marshall et al., 2010); whether transformation features, even if systems have radically altered (Pelling, 2010; Bene et al., 2012); and whether a whole host of other capacities and capitals, such as learning or anticipating, play distinct roles (Tschakert & Dietrich, 2010; Bahadur et al., 2015). An assumption therefore prevails that an evaluative tool's choice of resilience-capacities will have considerable implications for measured outcomes.

Yet, by comparing two popular resilience frameworks (3A and AAT), as well as a much larger set of 9 resilience-related capacities drawn across the wider literature (9C), we find very similar results – both with regards to correlations as well as associated socio-economic drivers (Fig. 7). Interestingly, the fact that Absorptive, Adaptive, Anticipatory and Transformative have the highest loadings in the first principal component of the PCA suggests that the resilience literature may be pointing in the right direction (and that differences between the mix of these four are of little importance). Of course, the limitations of subjectively-evaluated measures, and the potential for the influence of known biases, have to be considered. However, these findings present a challenge to lengthy debates over the exact composition of resilience-related capacities (Bahadur & Pichon, 2017). It may also lessen the burden placed on choosing the 'right' mix of resilience-related capacities used in measurement approaches – whether subjective or objectively-oriented.

Our findings also suggest that outcomes from shorter SERS modules largely mimic those in full range of resilience-related capacities. This is of critical importance in efforts to save survey space and reduce the time needed in interviewing households. As pressure grows on resilience evaluators to design tools that are ever cheaper and quicker to administer (Tiwari, Skoufias, & Sherpa, 2013), we believe that short subjectively-evaluated modules offer some promise.

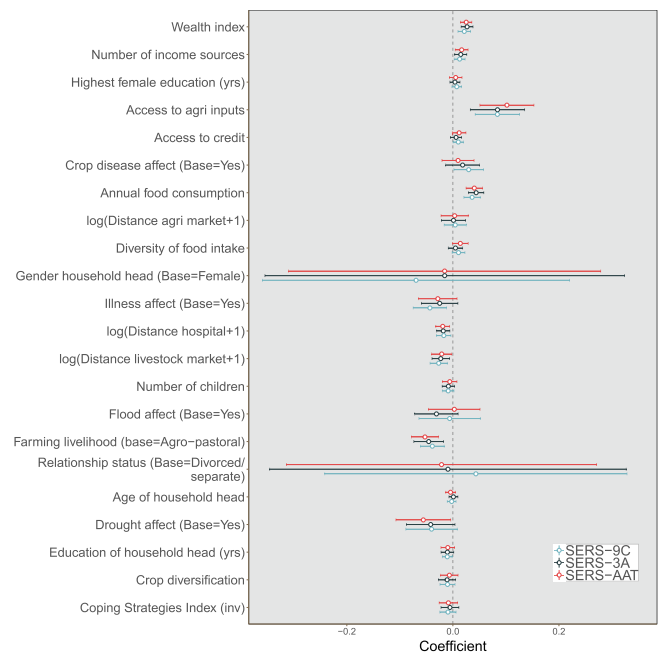


Fig. 7. Coefficient plot comparing different variants of the SERS subjectively-evaluated resilience model. Notes: Dots represent standardised beta coefficients, 95% confidence intervals are represented as whiskers. Standard errors are clustered at sub-county level.

d. Limitations and routes forward

In reflecting on the implications of our findings, we highlight a number of important considerations. Firstly, we reiterate that neither RIMA nor SERS should be interpreted as 'true' measures of resilience. They are both indirect attempts at approximating a household's resilience, with no means of validating either without continually tracking wellbeing over time. Instead, our findings highlight the importance of diversity in sources of knowledge for resilience. Having said that, we are reassured to see that two largely independent ways of measuring resilience show moderate correlations, and that our subjective module is associated with many of the same socio-economic drivers. To be clear, this largely infers that SERS outcomes closely match the indicators used in the RIMA model (as the socio-economic drivers chosen here largely match those used in formulating RIMA). The fact that other drivers differ entirely in terms of sign and significance also provides helpful impetus: challenging evaluators to re-examine long-held assumptions, and encouraging evidence-based selection of indicators.

As with any one-off survey, findings should be interpreted with some caution. Given the subjective nature of the SERS module, a number of cognitive biases may be at play. For example, questions within the subjective module follow the same sequencing and may have resulted in cognitive fatigue or acquiescence bias. This is especially relevant given the strong overlap in wording of questions and response-items. In addition, both the overall and hazard-specific SERS modules were placed closely together in the survey. Respondents may therefore be primed in their responses. More needs to be done to explore the role of cognitive influences on subjective measures of resilience before firm conclusions can be drawn. Practices such as reverse coding of response-items and randomisation of question and module order may be important next steps, and are planned in future iterations of this research.

More importantly, our findings point to the importance of encouraging resilience evaluators to be transparent about the merits and limitations of different approaches. For example, objectively-oriented measures (like RIMA) have the advantage of clear and comprehensive lists of standardised indicators. Yet, they struggle to account for factors that are not directly visible or tangible (Levine, 2014). Though subjective tools are by no means a silver bullet, they prove an alternative solution by giving individuals the chance to factor 'softer' aspects such as social capital, entitlement and power into their internal judgements of resilience (Maxwell et al., 2015; Jones & Tanner, 2017).

While some of these tradeoffs are relatively well known, others require further insights and careful research. One important question-mark for resilience measurement is how to deal with context-specificity (Zhou, Wan, & Jia, 2010). Objectively-evaluated approaches tend to have fixed indicators and weights, meaning that two households are measured in exactly the same way. While this brings advantages of direct comparison, it does not account for the fact that the supporting traits of household resilience in one country might be completely different to those in another (Pelling, 2010). Subjective measures don't rely on proxies, and as long as people view resilience in similar ways, should provide a valid way of comparing resilience across differing contexts. Sadly, the assumption of uniform views on resilience (just like happiness) is a large one, meaning that cross-cultural comparisons should be treated with caution (Ungar, 2008; Selin, 2003). Some methodological practices, such as anchoring vignettes, do however offer hope in this regard (King & Wand, 2007).

We also see considerable potential for combining subjective and objective approaches. Building on the strengths of each approach, it is certainly possible to design measures that mix elements of both: whether matching subjective definitions with objective evaluations, or through combining the use of objective indicators with self-assessments. Above all, we encourage evaluators to build on these findings, and capitalise on the advantages that both objective and subjective measures offer in promoting more diverse and comprehensive approaches to resilience measurement.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors are grateful to the reviewers for their incredible work on this paper. The authors are likewise grateful to the FAO Uganda Office and Uganda Bureau of Statistics and Office of Prime Minister for the support during the data collection in Karamoja. LJ recognises valuable financial contributions from the Economic and Social Research Council. Finally, they want to thank all the colleagues that have been providing support, comment and inputs.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.worlddev.2019.104632>.

References

- Adger, W. N. (1999). Social vulnerability to climate change and extremes in coastal Vietnam. *World Development*, 27(2), 249–269.
- Aldridge, D. P. (2012). *Building resilience: Social capital in post-disaster recovery*. University of Chicago Press.
- Alexander, D. E. (2013). Resilience and disaster risk reduction: An etymological journey. *Natural Hazards and Earth System Sciences*, 13(11), 2707–2716. <https://doi.org/10.5194/nhess-13-2707-2013>.
- Alinovi, L., Mane, E., & Romano, D. (2008). Towards the measurement of household resilience to food insecurity: Applying a model to Palestinian household data. In *Deriving food security information from national household budget surveys. Experiences, achievement, challenges* (pp. 137–152). Rome: FAO.
- Ayeb-Karlsson, S., van der Geest, K., Ahmed, I., Huq, S., & Warner, K. (2016). A people-centred perspective on climate change, environmental stress, and livelihood resilience in Bangladesh. *Sustainability Science*, 11(4), 679–694.
- Bahadur, A. V., Peters, K., Wilkinson, E., Pichon, F., Gray, K., & Tanner, T. (2015). *The 3As: Tracking resilience across BRACED Working and Discussion Papers*. London: Overseas Development Institute.
- Bahadur, A., & Pichon, F. (2017). *Analysis of resilience measurement frameworks and approaches*. London, UK: Overseas Development Institute [online] URL: <http://www.preventionweb.net/publications/view/52589>.
- Béné, C., Al-Hassan, R. M., Amarasinghe, O., Fong, P., Ocran, J., Onumah, E., ... Mills, D. J. (2016a). Is resilience socially constructed? Empirical evidence from Fiji, Ghana, Sri Lanka, and Vietnam. *Global Environmental Change*, 38, 153–170. <https://doi.org/10.1016/j.gloenvcha.2016.03.005>.
- Béné, C., Frankenberger, T., Langworthy, M., Mueller, M., & Martin, S. (2016b). The influence of subjective and psycho-social factors on people's resilience: Conceptual framework and empirical evidence. report prepared by the technical consortium, a project of the CGIAR. *Technical report series No. 2: Strengthening the evidence base for resilience in the Horn of Africa*. Nairobi: Kenya: A joint International Livestock Research Institute (ILRI) and TANGO International publication.
- Béné, C., Wood, R. G., Newsham, A., & Davies, M. (2012). *Resilience: new utopia or new tyranny? Reflection about the potentials and limits of the concept of resilience in relation to vulnerability reduction programmes* Working Paper 2012(405). Brighton: Institute of Development Studies.
- Berkes, F., & Turner, N. J. (2006). Knowledge, learning and the evolution of conservation practice for social-ecological system resilience. *Human Ecology*, 34(4), 479.
- Birkmann, J. (2006). Measuring vulnerability to promote disaster-resilient societies: Conceptual frameworks and definitions. *Towards Disaster Resilient Societies*, 1, 9–54.
- Bottazzi, P., Winkler, M., Boillat, S., Diagne, A., Maman Chabi Sika, M., Kpangon, A., ... Speranza, C. (2018). Measuring subjective flood resilience in suburban Dakar: A Before-after evaluation of the "Live with Water" project. *Sustainability*, 10(7), 2135.
- Brooks, N., Faget, D., & Hiejkoop, P. (2019). *Tools for measuring resilience in Nepal: Literature review*. London: UK: Department for International Development: Expert Advisory Call Down Services. Accessible at: https://assets.publishing.service.gov.uk/media/5c77c18e5274a3cc494e7b1/Resilience_measurement_LitRev_FINAL-updated1_ML_June_2019.pdf.
- Beauchamp, E., Abdella, J., Fisher, S., McPeak, J., Patnaik, H., Koulibaly, P., Cissé, D., Touré, M., Bocoum, A., Ndao, M., Deme, Y., & Gueye, B. (2019). Resilience from the ground up: how are local resilience perceptions and global frameworks aligned? *DISASTER*, 43(S3), S295–S317.
- Birkmann, J. (2006). *Measuring vulnerability to natural hazards. Towards disaster resilient societies* (p. 550). New York: United Nations Publications. US\$39 paper. ISBN: 978 92 808 1135 3.
- Claire, A., Graber, R., Jones, L., & Conway, D. (2017). Subjective measures of climate resilience: What is the added value for policy and programming? *Global Environmental Change*, 46, 17–22. <https://doi.org/10.1016/j.gloenvcha.2017.07.001>.
- Clare, A., Sagynbekova, L., Singer, G., Bene, B., & Rahmanberdi, A. (2018). *Can subjective resilience indicators predict future food security? Evidence from three communities in rural Kyrgyzstan* Centre for Climate Change Economics and Policy Working Paper 342/Grantham Research Institute on Climate Change and the Environment Working Paper 308. London: London School of Economics and Political Science.
- COSA (2017). *Simpler resilience measurement: tools to diagnose and improve how households fare in difficult circumstances from conflict to climate change*. Philadelphia, USA: The Committee on Sustainability Assessment. Accessible at: <https://thecosa.org/wp-content/uploads/2018/04/COSA-FORD-Simpler-Resilience-Measurement-Full-20180413.pdf>.
- Cox, R. S., & Perry, K. M. E. (2011). Like a fish out of water: Reconsidering disaster recovery and the role of place and social capital in community disaster resilience. *American Journal of Community Psychology*, 48(3–4), 395–411.
- Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). A place-based model for understanding community resilience to natural disasters. *Global Environmental Change*, 18(4), 598–606.
- Cutter, S. L., Burton, C. G., & Emrich, C. T. (2010). Disaster resilience indicators for benchmarking baseline conditions. *Journal of Homeland Security and Emergency Management*, 7(1).
- D'Errico, M., Grazioli, F., & Pietrelli, R. (2017). Cross-country evidence of the relationship between resilience and the subjective perception of well-being and social inclusion: Evidence from the regions of Matam (Senegal) and the triangle of hope (Mauritania). *Journal of International Development*. <https://doi.org/10.1002/jid.3335>.

- DFID. (2016). Measuring resilience. Evidence on demand report commissioned for the Department for International Development by Crown Agents. London UK. DOI: <http://dx.doi.org/10.12774/eod.tg.may2016.sturgess2>.
- Dolan, P., & Metcalfe, R. (2012). Measuring subjective wellbeing: Recommendations on measures for use by national governments. *Journal of Social Policy*, 41(2), 409–427. <https://doi.org/10.1017/s0047279411000833>.
- D. Wilson & G. Yaron. (2016). Laying the foundations for measuring resilience. https://www.itad.com/wp-content/uploads/2016/09/BRCJ4791_Working_Paper_09.16_WEB.pdf.
- FAO (2016). *RIMA 2: Resilience index measurement and analysis 2*. Rome: Italy: United Nations Food and Agriculture Organisation. URL: <http://www.fao.org/3/a-i5665e.pdf>.
- Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C. S., & Walker, B. (2002). Resilience and sustainable development: Building adaptive capacity in a world of transformations. *AMBIO: A Journal of the Human Environment*, 31(5), 437–440.
- Foster, K. A. (2007). *A case study approach to understanding regional resilience* Working Paper. Buffalo, NY: UB Institute.
- Frankenberger, Timothy R., & Katherine McCaston, M. (1998). The household livelihood security concept. *Food Nutrition and Agriculture*, 30–35.
- Few, R., Morchain, D., Spear, D., Mensah, A., & Bendapudi, R. (2017). Transformation, adaptation and development: Relating concepts to practice. *Palgrave Communications*, 3, 17092.
- FSIN. (2014). Resilience measurement principles: toward an agenda for measurement design. Food Security Information Network: Resilience Measurement Technical Working Group. Rome: Italy. Accessible at: http://www.fao.org/fileadmin/user_upload/drought/docs/FSIN%20Resilience%20Measurement%20201401.pdf.
- Gartrell, B. (1985). Searching for “The Roots of Famine: The case of Karamoja. *Review of African Political Economy*, 33, 102–110.
- Hall, T. E., & Slothower, M. (2009). Cognitive factors affecting homeowners' reactions to defensible space in the Oregon coast range. *Society and Natural Resources*, 22, 95–110.
- Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review Ecology and Systematics*. <https://doi.org/10.1146/annurev.es.04.110173.000245>.
- HSSAI (2015). *Measuring for results: Application of key concepts to resilience measurement*. Falls Church: USA: Homeland Security Studies and Analysis Institute (HSSAI). Accessible at: <https://www.anser.org/docs/reports/HSSAI-Report-MeasuringforResults-ApplicationofKeyConceptstoResilienceMeasurement-10-12-15.pdf>.
- Selin, H. (2003). *Nature across cultures: views of nature and the environment in non-western cultures*. Kluwer, Dordrecht, The Netherlands. http://dx.doi.org/10.1007/978-94-017-0149-5_17.
- Ibarrarán, M. E., Ruth, M., Ahmad, S., & London, M. (2009). Climate change and natural disasters: Macroeconomic performance and distributional impacts. *Environment, Development and Sustainability*, 11(3), 549–569.
- Jabeen, H., Johnson, C., & Allen, A. (2010). Built-in resilience: Learning from grassroots coping strategies for climate variability. *Environment and Urbanization*, 22(2), 415–431.
- Jean, H., Castillo, G. E., & Thomas, S. (2017). *Absorb, adapt, transform: Resilience capacities*. Oxford: UK: Oxfam Great Britain. Accessible at: <https://oxfamlibrary.openrepository.com/bitstream/handle/10546/620178/gd-resilience-capacities-absorb-adapt-transform-250117-en.pdf?sequence=4&isAllowed=y>.
- Jones, L., Ludi, E., & Levine, S. (2010). *Towards a characterisation of adaptive capacity: A framework for analysing adaptive capacity at the local level*. UK London: Overseas Development Institute.
- Jones, L. (2019). Resilience isn't the same for all: Comparing subjective and objective approaches to resilience measurement. *Wiley Interdisciplinary Reviews: Climate Change*, 10(1). <https://doi.org/10.1002/wcc.552>.
- Jones, L. (2017). *New methods in resilience measurement: Early insights from a mobile phone panel survey in Myanmar using subjective tools*. London: UK: Overseas Development Institute.
- Jones, L., & Tanner, T. (2017). Subjective resilience: Using perceptions to measure household resilience to climate extremes and disasters. *Regional Environmental Change*, 17, 229–243. <https://doi.org/10.1007/s10113-016-0995-2>.
- Jones, L., & Samman, E. (2016). *Measuring subjective household resilience: Insights from Tanzania*. London: UK: Overseas Development Institute (ODI).
- Jones, L., Samman, E., & Vinck, P. (2018). Subjective measures of household resilience to climate variability and change: Insights from a nationally representative survey of Tanzania. *Ecology and Society*, 23(1), 9.
- Kahn, M. E. (2005). The death toll from natural disasters: The role of income, geography, and institutions. *Review of Economics and Statistics*, 87(2), 271–284.
- Kates, R. W., Travis, W. R., & Wilbanks, T. J. (2012). Transformational adaptation when incremental adaptations to climate change are insufficient. *Proceedings of the National Academy of Sciences*, 109(19), 7156–7161.
- Keil, A., Zeller, M., Wida, A., Sanim, B., & Birner, R. (2008). What determines farmers' resilience towards ENSO-related drought? An empirical assessment in Central Sulawesi, Indonesia. *Climatic Change*, 86(3–4), 291.
- Kelman, I., Gaillard, J. C., & Mercer, J. (2015). Climate change's role in disaster risk reduction's future: Beyond vulnerability and resilience. *International Journal of Disaster Risk Science*, 6(1), 21–27.
- King, G., & Wand, J. (2007). Comparing incomparable survey responses: Evaluating and selecting anchoring vignettes. *Political Analysis*, 15(1), 46–66.
- Kristoffersen, I. (2017). The metrics of subjective wellbeing data: An empirical evaluation of the ordinal and cardinal comparability of life satisfaction scores. *Social Indicators Research*, 130(2), 845–865.
- Levine, S. (2010). An unromantic look at pastoralism in karamoja: How hard-hearted economics shows that pastoral systems remain the solution, and not the problem. *Nomadic Peoples*, 14(2), 147–153.
- Levine, S. (2014). *Assessing resilience: Why quantification misses the point*. Humanitarian Policy Group, Overseas Development Institute. Available online at: <http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9049.pdf>.
- Magis, K. (2010). Community resilience: An indicator of social sustainability. *Society and Natural Resources*, 23(5), 401–416.
- Marshall, N. A. (2010). Understanding social resilience to climate variability in primary enterprises and industries. *Global Environmental Change*, 20.1, 36–43. <https://doi.org/10.1016/j.gloenvcha.2009.10.003>.
- Marshall, N. A., Marshall, P. A., Tamelander, J., Obura, D., Malleret-King, D., & Cinner, J. E. (2010). *A framework for social adaptation to climate change: Sustaining tropical coastal communities [sic] and industries*. Gland, Switzerland: International Union of Conservation of Nature (IUCN).
- Maxwell, D., Constan, M., Frankenberger, T., Klaus, D., & Mock, M. (2015). *Qualitative data and subjective indicators for resilience measurement. Resilience measurement technical working group. Technical Series No. 4*. Rome: Food Security Information Network. Available online at: <http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9049.pdf>.
- Mayunga, J. (2007). Understanding and applying the concept of a community disaster resilience: A capital-based approach. *Working paper for the summer academy for social vulner ability and resilience building*, 22–28 July 2007. Munich: Germany.
- Miceli, R., Sotgiu, I., & Settanni, M. (2008). Disaster preparedness and perception of flood risk: A study in an Alpine Valley in Italy. *Journal of Environmental Psychology*, 28, 164–173.
- Miller, F., Osbahr, H., Boyd, E., Thomalla, F., Bharawani, S., Ziervogel, G., ... Hinkel, J. (2010). Resilience and vulnerability: Complementary or conflicting concepts? *Ecology and Society*, 15(3), 1–25.
- Ho, M.-C., Shaw, D., Lin, S., & Chiu, Y.-C. (2008). How Do Disaster Characteristics Influence Risk Perception? *Risk Analysis*, 28(3), 635–643.
- Nguyen, K. V., & James, H. (2013). Measuring resilience to floods: A case study in the Vietnamese Mekong River Delta. *Ecology and Society*, 18.3, 13. <https://doi.org/10.5751/es-05427-180313>.
- O'Brien, K. L., & Leichenko, R. M. (2000). Double exposure: Assessing the impacts of climate change within the context of economic globalization. *Global Environmental Change*, 10(3), 221–232.
- O'Sullivan, J. J., Bradford, R. A., Bonaio, M., Dominici, S. D., Rotko, P., Aaltonen, J., ... Langan, S. J. (2012). Enhancing flood resilience through improved risk communications. *Natural Hazards and Earth System Sciences*, 12(7), 2271–2282.
- O'Brien, G., O'Keefe, P., Gadema, Z., & Swords, J. (2010). Approaching disaster management through social learning. *Disaster Prevention and Management: An International Journal*, 19(4), 498–508.
- OECD (2013a). *OECD guidelines on measuring subjective well-being*. Paris: France: OECD Publishing. Accessible at: <https://www.oecd.org/statistics/oecd-guidelines-on-measuring-subjective-well-being-9789264191655-en.htm>.
- OECD (2013b). *OECD guidelines on measuring subjective well-being*. Paris: France: OECD Publishing.
- Olsson, L., Jerneck, A., Thoren, H., Persson, J., & O'Byrne, D. (2015). Why resilience is unappealing to social science: Theoretical and empirical investigations of the scientific use of resilience. *Science Advances*, 1(4). <https://doi.org/10.1126/sciadv.1400217>.
- Opiyo, F., Wasonga, O., Nyangito, M., Schilling, J., & Munang, R. (2015). Drought adaptation and coping strategies among the Turkana pastoralists of northern Kenya. *International Journal of Disaster Risk Science*, 6(3), 295–309.
- Paton, D. (2003). Disaster preparedness: A social-cognitive perspective. *Disaster Prevention and Management: An International Journal*, 12(3), 210–216.
- Pelling, M. (2010). *Adaptation to climate change: From resilience to transformation*. Routledge.
- Pisello, A. L., Rosso, F., Castaldo, V. L., Piselli, C., Fabiani, C., & Cotana, F. (2017). The role of building occupants' education in their resilience to climate-change related events. *Energy and Buildings*, 154, 217–231.
- Pingali, P. L., Alinovi, L., & Sutton, J. (2005). Food security in complex emergencies: enhancing food system resilience. *Disasters*. <https://doi.org/10.1111/j.0361-3666.2005.00282.x>.
- Renschler, C. S., Frazier, A. E., Arendt, L. A., Cimellaro, G. P., Reinhorn, A. M., & Bruneau, M. (2010). *A framework for defining and measuring resilience at the community scale: The PEOPLES resilience framework* (pp. 10–16). Buffalo: MCEER.
- Roberts, E., Andrei, S., Huq, S., & Flint, L. (2015). Resilience synergies in the post-2015 development agenda. *Nature Climate Change*, 5(12), 1024.
- Rose, A. (2004). Defining and measuring economic resilience to disasters. *Disaster Prevention and Management: An International Journal*, 13(4), 307–314.
- Ruin, I., Gaillard, J. C., & Lutoff, C. (2007). How to get there? Assessing motorists' flash flood risk perception on daily itineraries. *Environmental Hazards*, 7, 235–244.
- Schipper, E. L. F., & Langston, L. (2015). *A comparative overview of resilience measurement frameworks: analysing indicators and approaches* ODI Working Paper 422. London: Overseas Development Institute.
- Scolobig, A., De Marchi, B., & Borga, M. (2012). The missing link between flood risk awareness and preparedness: Findings from case studies in an Alpine Region. *Natural Hazards*, 63(2), 499–520.
- Seara, T., Clay, P. M., & Colburn, L. (2016). Perceived adaptive capacity and natural disasters: A fisheries case study. *Global Environmental Change*, 38, 49–57. <https://doi.org/10.1016/j.gloenvcha.2016.01.006>.

- Sherrieb, K., Norris, F. H., & Galea, S. (2010). Measuring capacities for community resilience. *Social Indicators Research*, 99(2), 227–247.
- Silbert, M., & Useche, M. (2012). *Repeated natural disasters and poverty in Island nations: A decade of evidence from Indonesia* PURC Working Paper. University of Florida, Department of Economics.
- Sutton, S., & Tobin, R. (2012). Social resilience and commercial fishers' responses to management changes in the Great Barrier Reef Marine Park. *Ecology and Society*, 17(3). <https://doi.org/10.5751/es-04966-170306>.
- Thomalla, F., & Larsen, R. K. (2010). Resilience in the context of tsunami early warning systems and community disaster preparedness in the Indian Ocean region. *Environmental Hazards*, 9(3), 249–265.
- Tiwari, S., Skoufias, E., & Sherpa, M. (2013). *Shorter, cheaper, quicker, better: Linking measures of household food security to nutritional outcomes in Bangladesh, Nepal, Pakistan, Uganda, and Tanzania*. Washington, DC: USA: The World Bank.
- Toole, S., Klocker, N., & Head, L. (2016). Re-thinking climate change adaptation and capacities at the household scale. *Climatic Change*, 135(2), 203–209. <https://doi.org/10.1007/s10584-015-1577-x>.
- Tschakert, P., & Dietrich, K. A. (2010). Anticipatory learning for climate change adaptation and resilience. *Ecology and Society*, 15(2).
- Tyler, S., & Moench, M. (2012). A framework for urban climate resilience. *Climate and Development*, 4(4), 311–326.
- Thywissen, K. (2006) Components of Risk: A Comparative Glossary. Source No. 2/ 2006. UNU-EHS, Bonn, 52.
- Twigg, J. (2009). Characteristics of a Disaster-Resilient community. <http://discovery.ucl.ac.uk/1346086/1/1346086.pdf>.
- Ungar, M. (2008). Resilience across cultures. *The British Journal of Social Work*, 38(2), 218–235.
- United Nations (2015a). *Transforming our world: The 2030 agenda for sustainable development*. Washing D.C.: USA: United Nations. USA.
- United Nations (2015b). *Adoption of the Paris agreement*. Paris: France: United Nations Framework Convention on Climate Change.
- Wachinger, G., Renn, O., Begg, C., & Kuhlicke, C. (2013). The risk perception paradox—Implications for governance and communication of natural hazards. *Risk Analysis*, 33(6), 1049–1065.
- Walker, B. H., Ludwig, D., Holling, C. S., & Peterman, R. M. (1981). Stability of semi-arid savanna grazing systems. *Journal of Ecology*, 69.2, 473–498. <https://doi.org/10.2307/2259679>.
- Windle, G., Bennett, K. M., & Noyes, J. (2011). A methodological review of resilience measurement scales. *Health and Quality of Life Outcomes*, 9(1), 8.
- Zhou, H., Wan, J., & Jia, H. (2010). Resilience to natural hazards: A geographic perspective. *Natural Hazards*, 53(1), 21–41.
- Zobel, C. W., & Khansa, L. (2014). Characterizing multi-event disaster resilience. *Computers & Operations Research*, 42, 83–94.